1979 Subtropical Food Technology Conference

OCTOBER 10, 1979

LANDMARK MOTOR LODGE

WINTER HAVEN, FLORIDA

U. S. CITRUS AND SUBTROPICAL PRODUCTS LABORATORY

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SOUTHERN REGION – FLORIDA ANTILLES AREA

SCIENCE AND EDUCATION ADMINISTRATION

U. S. DEPARTMENT OF AGRICULTURE

PREFACE

The Annual Subtropical Food Technology Conference is sponsored by the Southern Region, Florida Antilles Area, of USDA's Science and Education Administration. It reports developments in the broad areas of processing, marketing, nutrition, solar applications, energy conservation and related subjects, and provides for exchange of information that will benefit the industry, future research and American consumers.

This report summarizes the statements of the various speakers during the Conference. Many of these are progress reports and are subject to change as studies are completed. Please contact authors for latest results before using these reports as a reference.

Dean F. Davis, Area Director

PROGRAM

1979 SUBTROPICAL FOOD TECHNOLOGY CONFERENCE

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Florida Citrus Research Foundation
(Supported by the Florida Department of Citrus)
Lakeland, Florida

GLASS CAPILLARY GAS CHROMATOGRAPHIC ANALYSIS OF CITRUS COLD-PRESSED OIL

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The major volatile flavor constituents of cold-pressed grapefruit oil were separated on a 30 m glass capillary column coated with Carbowax 20M, and analytical results were determined using internal standard and normalization methods capabilities of a microprocessor controlled gas chromatographic (gc) terminal. Results were compared to previously reported literature values. Of the 34 identified constituents, 30 were quantitated. Newly quantitated compounds include β-pinene, sabinene, cis- and trans-limonene oxide, octanol, neral, dodecanal, and geranyl acetate. Compounds identified but not quantitated include 1,8-cineol, and cis- and trans-linalool oxide.

Quantitative analytical data for cold-pressed grapefruit oil.

	Quantitative values			
	Capillary		Packed	
Component	Int Std	Norm	Norm[a]	Lit[b]
α-Pinene	0.38	0.39	-	-
β-Pinene	0.05	0.04	-	-
Sabinene	1.08	1.04	-	0.7
Myrcene	3.67	3.41	2.12	1.4-2.1
Limonene	84.84	83.66	85.60	86-95
γ-Terpinene	0.12	0.12	-	0.5-0.8
Octanal	0.79	0.81	0.71	0.3-0.7
Nonanal	0.12	0.23	0.04	.04-0.1
c-Limonene oxide	0.09	0.09	-	-
t-Limonene oxide	0.04	0.05	-	-
Octyl acetate	0.05	0.05	0.09	-
Citronellal	0.13	0.13	0.14	-
Decanal	0.46	0.49	0.60	0.3-0.6
α-Copaene	0.06	0.07	0.06	-
Linalool	0.14	0.13	0.30	0.3-0.4
Octanol	0.04	0.04	-	-
β-Copaene	0.04	0.02	0.01	-
β-Elemene	0.02	0.06	0.06	-
Caryophyllene	0.25	0.31	0.25	-
Citronellyl acetate	0.06	0.04	-	-
Neral	0.11	0.07	-	-
α-Terpineol	0.05	0.04	-	0.03
Humulene	0.07	0.07	-	-
Dodecanal	0.22	0.21	-	0.1
Neryl acetate	0.02	0.02	0.22	0.1-0.2
Geranial	0.11	0.08	0.11	-

Table continued:

Component	Quantitative values: Capillary Int Std	Capillary Norm	Packed Norm[a]	Packed Lit[b]
Carvone	0.02	0.02	-	-
Geranyl acetate	0.04	0.04	-	0.1-0.2
Δ-Cadinene	0.12	0.07	0.11	-
Perillaldehyde	0.07	0.02	0.20	-
Elemol	0.04	0.04	0.04	-
Nootkatone	0.02	0.03	-	0.3-0.8

[a]Wilson, C. W. III, and Shaw, P. E. J. Agric. Food Chem. 26:1432 (1978).

[b]Shaw, P. E. J. Agric. Food Chem. 27:246 (1979).

SEARCH FOR NEW FLAVOR AND OFF-FLAVOR COMPOUNDS IN CITRUS JUICES AND OILS

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Essence oil from overripe oranges was analyzed for phenolic ethers found earlier in oranges treated with rind-injuring abscission agents (1). These phenolic ethers (eugenol, methyl eugenol, elemicin, cis- and trans-methyl iso-eugenols, and trans-iso-elemicin) had been found responsible for the "overripe" aroma and flavor in abscission treated fruit. Several compounds, not previously reported as essence oil constituents, were identified (Table 1, footnote a), but none of the phenolic ethers were found. Table 1 lists all essence oil components identified in this study. One finding of possible practical significance was that valencene was present in this overripe essence oil at about twice the level normally found in essence oil. Thus, this increase appears to make essence oil from overripe oranges a better source for this valuable sesquiterpene than that previously believed to be the best source for obtaining valencene.

In other flavor work, a sensitive method for determining volatile sulfur-containing compounds was used to quantitate hydrogen sulfide and methyl sulfide in headspace gases of orange and grapefruit juices (Table 2). Other volatile sulfur-containing compounds (COS, SO_2, MeSH and higher allkyl sulfides) not previously reported as citrus constituents were detected in some samples. Studies in which headspace gases were spiked with H_2S suggested that the aqueous solution reacted with H_2S to produce the other volatile sulfur-containing compounds. Aroma tests indicated these sulfides influence juice flavor at about the levels found in fresh fruit.

Table 1. Orange essence oil components identified in this study.

Alcohols	Esters
cis-Carveol	1,8-*p*-Menthadiene-9-yl acetate[a]
trans-Carveol	Octyl acetate[a]
Citronellol	
Decanol	**Hydrocarbons**
Dodecanol	β-Caryophyllene
Elemol[a]	α-Copaene
Geraniol[a]	β-Copaene
Linalool	β- Cubebene
Intermedeol[a]	*p*-Cymene
1,8-*p*-Menthadiene-9-ol[a]	β-Elemene
cis-2,8-*p*-Menthadiene-1-ol	Limonene
trans-2,8-*p*-Menthadiene-1-ol	Myrcene
Nerol[a]	Nootkatene[a]
Nonanol	α-Pinene
Octanol	epi-α-Selinene[a]
α-Terpineol	Valencene
Aldehydes	**Ketones**
Decanal	Carvone
Dodecanal[a]	Nootkatone[a]
Geranial	Piperitenone
Octanal	
Perillaldehyde	**Miscellaneous**
α-Sinensal[a]	*trans*-Linalool oxide[a]
β-Sinensal[a]	

[a]Constituents of orange essence oil being reported for the first time.

LITERATURE CITED

1. Moshonas, M. G. and P. E. Shaw. J. Agric. Food Chem. 26:1288 (1978).

Table 2. Determination of volatile sulfur-containing compounds in headspace gases of orange and grapefruit juices.

Juice sample (time)[a]	Quantity present (ppb in headspace gases)					
	H_2S	Me_2S	MeSH	SO_2	COS	Other S
Marsh grapefruit						
10 min	1.9	0.5	N[b]	+[c]	+	N
Calif. Navel orange A[d]						
42 min	11	3.5	N	+	+	N
60 min	18	3.3	+	+	+	N
Calif. Navel orange B[d]						
5 min	26	0.5	N	N	N	N
28 min	22	+	N	N	N	N
Spiked 60 min[e]	23	12	+	+	+	+
Valencia orange A[d]						
45 min	2.0	N	N	N	N	N
Valencia orange B[d]						
10 min[f]	1.9	0.5	N	+	+	N
Reconst. FCOJ						
7 min[g]	2.6	N	N	N	N	N
Spiked 8 min[h]	10	11	+	+	+	+
Distilled water blank						
1 min	N	N	N	N	N	N
Spiked 10 min[i]	+	+	+	+	+	+

[a] Time is in min after juice extracted, unless otherwise noted.

[b] N = not detected.

[c] (+) = present, but not quantited (not major fraction).

[d] Samples A and B are two different fresh juice samples from same batch of oranges.

[e] Spiked with 10 µl H_2S in headspace gases at 53 min, then let stand 1 hr.

[f] Larger (3.4 l) trap sample collected than for other trap samples.

[g] Time after juice reconstituted to single-strength.

[h] Spiked with 10 µl H_2S in headspace gases at 60 min, then let stand 8 min.

[i] Spiked with 10 µl H_2S in headspace gases initially, then let stand 10 min.

METHANOL, ACETALDEHYDE AND ETHANOL IN CITRUS PRODUCTS

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Determination of quality related volatiles in citrus has been carried out by headspace techniques or preconcentration followed by gas chromatography (gc). For the three predominant volatiles, methanol, ethanol and acetaldehyde, a simpler direct injection gc method is possible. Application of a rapid method would make it possible to screen citrus products for correlations of volatiles profile with quality related factors such as Brix, acid, flavor or pulp content.

In this study, we determined concentrations of the three volatiles in single-strength (canned and glass-packed) and concentrated orange and grapefruit juice and in grapefruit sections by direct injection gc. The results were compared with previously reported values. Correlations between volatiles profile and characteristic quality-related parameters were also studied.

Table 1 shows concentrations of the three compounds in single-strength and concentrated orange and grapefruit juice. Values for grapefruit sections are shown at the bottom of the table. Concentrate contained more acetaldehyde and less of the two alcohols than single-strength juice. Several of the concentrates had a volatiles profile similar to single-strength juice, but from the ratio of methanol to ethanol, it was concluded that essence had been added to these samples. Grapefruit juices tended to be lower in the alcohols and higher in acetaldehyde than the corresponding orange juices.

A study of stored and heat-treated fresh juice showed that methanol increased and acetaldehyde decreased in orange juice stored at room temperature. In contrast, methanol decreased and acetaldehyde increased during pasteurization of orange and grapefruit juice. Ethanol was not affected as much as the other two.

A possible correlation between ethanol and date processed was observed for single-strength juice. Otherwise, there were no apparent correlations between volatiles and other juice parameters.

A storage study was carried out on commercial single-strength juice and grapefruit sections at 83°F. No significant change was observed in any of the 3 volatiles in stored canned or glass-packed single strength juice. Off-flavor development in canned and bottled (non-heat-treated) sections was correlated with an increase in methanol and ethanol, respectively.

Although some of the correlations are tentative, a number of them seem to have potential as methods for quality evaluation or detection of storage abuse.

Table 1. Volatiles concentration.

Sample		Concentration, wt/vol % x 10^2		
		Methanol	Acetaldehyde	Ethanol
Orange				
Single-strength[a]	R[b]	(0.11-0.8)	(0.5-1.3)	(1.50-9)
	M	0.34	0.90	5.3
Concentrate[c]	R	(0-0.19)	(1.00-1.9)	(0.03-4)
	M	0.054	1.35	1.17
Grapefruit				
Single-strength[d]	R	(0.13-0.4)	(0.4-2.3)	(0.9-5)
	M	0.274	1.54	2.38
Concentrate[e]	R	(0-0.09)	(1.4-2.2)	(0.0025-0.05)
	M	0.022	1.89	0.0158
Sections (syrup)	R	(0.5-1.5)	(0.6-1.8)	(1.0-3)
	M	0.74	1.26	1.81

[a] 25 samples

[b] R-range, M-mean

[c] 10 samples, reconstituted

[d] 26 samples

[e] 4 samples, reconstituted

A RAPID AUTOMATED MICROBIOLOGICAL DETERMINATION OF ORANGE JUICE AUTHENTICITY

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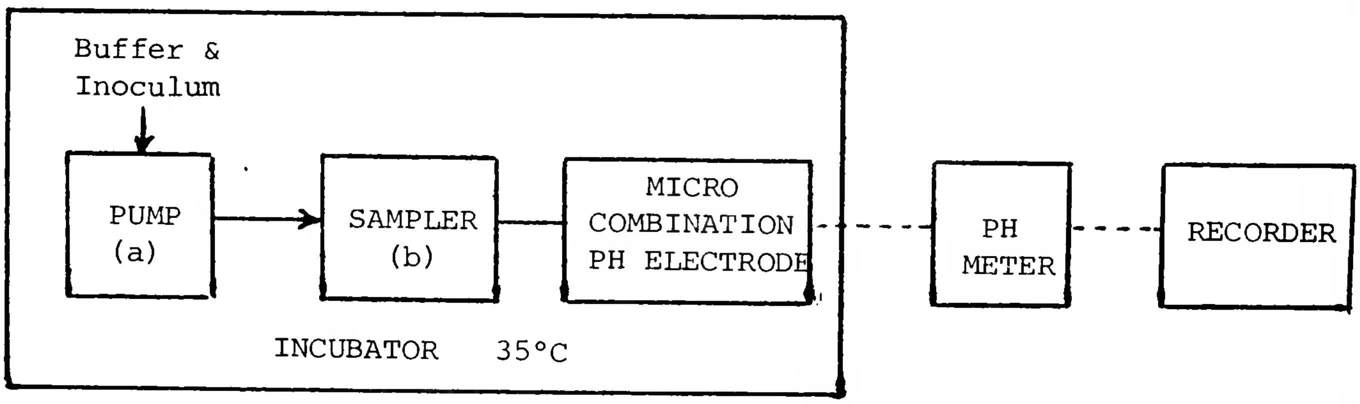
In our continuing work on methodology for detecting adulteration in orange juice we previously reported a microbiological assay using *Lactobacillus plantarum*. This organism requires many nutrients to grow and, hence, simultaneously assays a number of compounds which are also important for human nutrition. Although microbiological assays are useful in that they determine biologically active forms of the nutrients, the assays are generally time-consuming and labor-intensive. We have now automated the assay to eliminate most of the manual manipulations and reduce the assay time from over 30 hours to less than two hours. Commercially available components were assembled into a system to automatically prepare, inoculate, incubate and measure samples of orange juice. The assay was based on the rate of pH change due to acid production by a massive inoculation of *Lactobacillus plantarum*. The rate of pH change was highly correlated with orange juice concentration.

Instrumentation

A schematic of the component arrangement is as follows:



(a) Technicon Proportioning Pump II
(b) Technicon Sampler II

Reagents

(a) A buffered glucose solution was made up with sodium phosphate (0.01 *M*) buffer at pH 6.8 containing 1% glucose.

(b) The inoculum consisted of washed cells of *L. plantarum* as a standardized suspension in dilute saline.

Procedure

Single strength orange juice was filtered through cheese cloth to remove large pulp particles. The filtrate was used without further treatment. Blended authentic orange juice of a type similar to the unknown samples was selected as the "standard" and the other juices were related to it. Aliquots of from 10 to 50 µl of pulp-free orange juice were added by syringe to the cups in the sampler tray. Cups without orange juice were included as blanks.

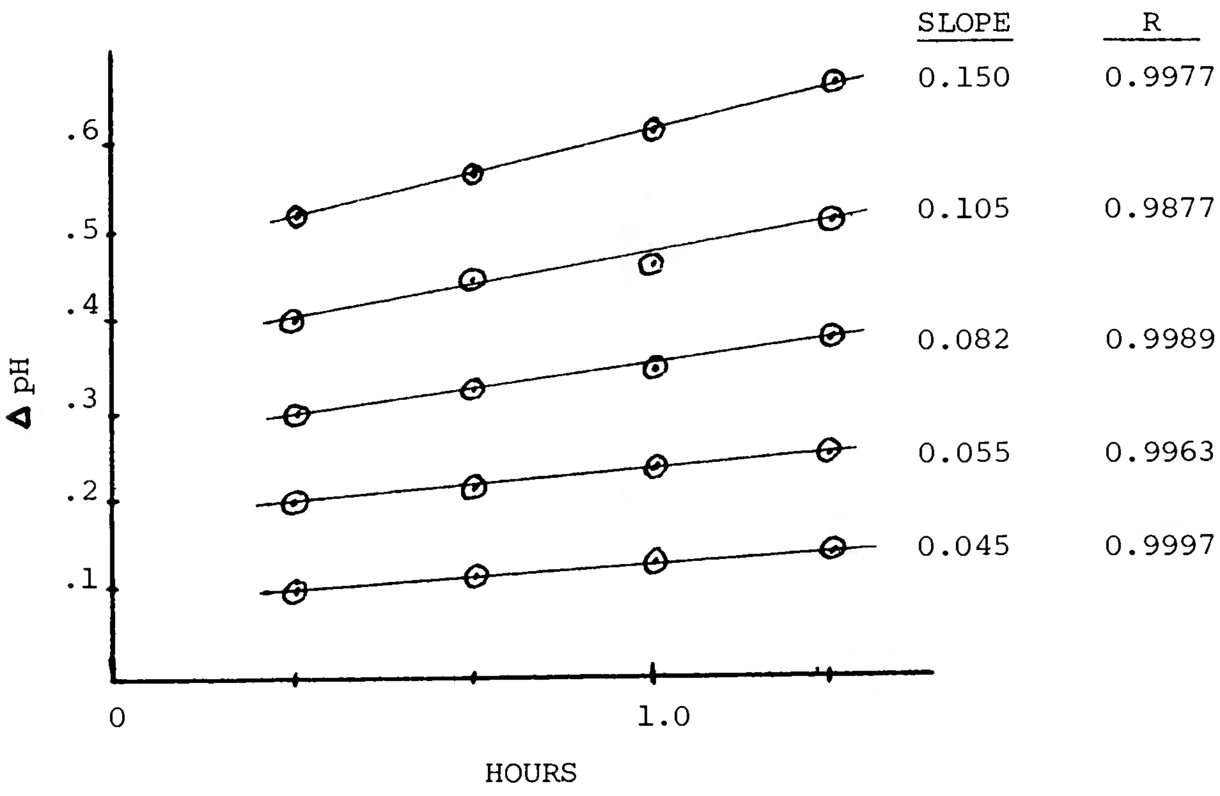
The inoculum and glucose-buffer solution were pumped for several minutes to attain a steady flow, and then the sampler unit was turned on. Thus, as the sample tray advanced, each cup was automatically filled with the reagents to sequentially start the incubation period. After the sample dilution-inoculation step the recorder was turned on, and the sampler and pump (without reagents) continued to run through four more cycles. At the end of the run bleach was pumped through the lines to sterilize the system.

Calculations

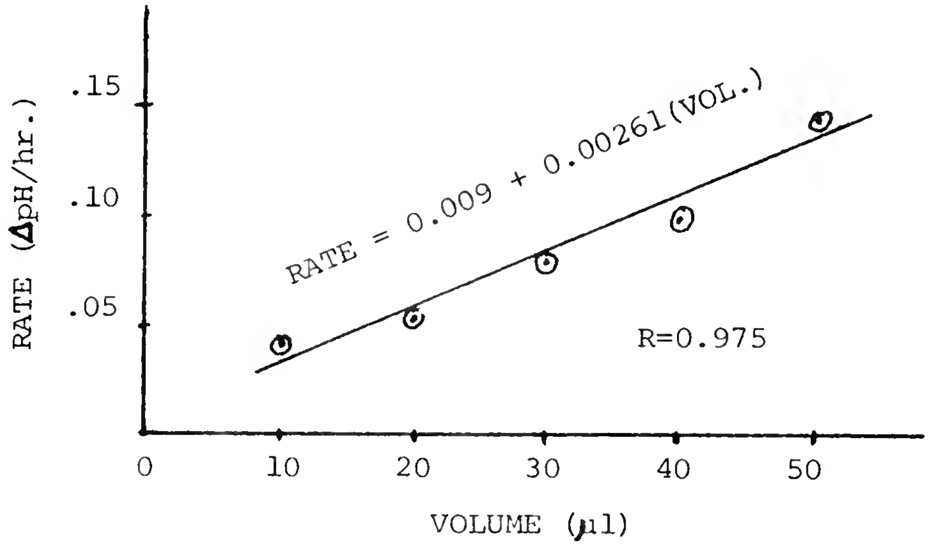
A baseline was drawn on the recorder chart connecting the blanks for each time cycle. Peak heights from the blank baseline were measured with a scale calibrated in pH units and were designated as the ΔpH values. The predicted concentration (as volume of juice added) was calculated as a function of time and change in pH by a standard multiple regression approach. The equation for the orange juice standard was used to calculate the predicted concentration for the unknown samples. The ratio of the measured to predicted volume was an estimate of juice concentration for the unknowns.

Results

To illustrate the principles involved, the change in pH (ΔpH) *vs* time plots for the standard are shown below:



Several points should be noted. Under the conditions selected, pH is linear in this time range, and it shows a high correlation with time. The selection of the buffer concentration is important, since the system in essence represents a pH titration curve in the more or less linear buffer region. A buffer of low strength would be overcome by the acid produced and would be out of the effective buffering region. On the other hand, a high buffer strength would be relatively insensitive to small changes in acid. The rate of metabolism or acid production of the bacteria increases as the amount of orange juice increases. This is shown in the following figure where the slope of the pH-time curve is



plotted against the volume of juice added. This relationship also shows a high linear correlation.

The data from a typical experiment showing pH as a function of time and juice content are presented in the following table:

		TIME				MULTPL. REGR. EQN.*				Ratio
Sample	VOL	20	40	60	80	A	B1	B2	R	PRED/MEAS
Standard Orange Juice	10	.095	.111	.125	.140	7.11	-7.44	85.2	0.995	---
	20	.194	.212	.227	.250					
	30	.292	.320	.344	.375					
	40	.400	.442	.461	.510					
	50	.510	.557	.602	.662					
Orange Juice #1	10	.100	.108	.118	.135	6.28	-6.49	82.3	.995	1.04
	25	.250	.275	.299	.328					
	40	.415	.456	.494	.541					
Orange Juice #2	10	.110	.116	.129	.141	4.97	-5.66	80.7	.997	1.07
	25	.270	.290	.311	.339					
	40	.441	.472	.509	.551					
Orange Juice #3	10	.089	.100	.108	.120	5.02	-6.36	100.1	.996	0.87
	25	.220	.241	.260	.284					
	40	.354	.386	.415	.452					

* VOL= A + B1 (Time) + B2 (ΔpH)

The multiple regression equations for the orange juice standard and samples are quite similar as are the coefficients of multiple correlation R. Estimates of juice content based on the multiple regression approach shows a relatively narrow range of values. For 72 retail samples the average percentage of orange juice and standard deviation are 99.5% $\pm$ 12.8%, respectively.

The time-consuming sample preparation steps of the manual microbiological assay which included preliminary centrifugation, pH adjustment, dilution, and sterilization, were eliminated in the present system. Adjustment of pH is unnecessary because the rate of change of pH is used instead of the absolute value. Sterile conditions in the pH readout stage don't seem to be necessary due to the massive inoculation of L. plantarum and the short incubation time. Incubated runs without inoculation have shown no change in pH in three hours.

The principles behind this analysis are different from the typical microbiological assay where a relatively few cells are allowed to grow in the medium to the point of exhaustion of an essential nutrient. In the present system it is the rate of metabolism which is proportional to concentration of the juice. There is a small but significant basal rate of metabolism for the bacteria in the blank with just glucose and buffer. The calculation step subtracts the metabolic rate for the blank from that of the orange-juice containing samples to eliminate the effect of the changing baseline. This assay was tested on a commercial, orange-flavored, dry beverage mix fortified with vitamins C and A. The results for the synthetic beverage were not significantly ($P<0.01$) different from the blank.

The system has potential applications for other microbiological assays, of vitamins for example. Specific-ion electrodes are a possible measuring approach for non-acid producing bacteria. The bacterial metabolites could also be measured indirectly by withdrawing an aliquot from each sample cup during each cycle and mixing it with appropriate reagents for a colorimentric readout. These and other applications are currently being investigated.

LIPIDS ASSOCIATED WITH VA MYCORRHIZAL FUNGUS INFECTED CITRUS ROOTS

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Vesicular-arbuscular mycorrhizal fungi have beneficial effects on growth of citrus seedlings on soils deficient in nutrients such as phosphorus. These organisms enhance uptake of phosphorus, producing growth similar to that of well-fed plants (1,2). The lipid composition of fibrous roots of seedlings and these fungi are of interest since preliminary histochemical analyses have revealed lipids to be more prevalent in roots of mycorrhizal infected seedlings than in controls.

Six citrus rootstocks were grown in pots with sterilized soil. They were inoculated with one of three Glomus species (M): G. mosseae, G. fasciculatus or G. etunicatus, while controls (C) were not inoculated. Control plants became stunted and chlorotic while the inoculated seedlings showed normal growth. Lipids were extracted from roots and fungi by conventional means. Analyses revealed a 3-10 fold increase in triglycerides and a 1.5-2.5 fold increase in phospholipids in inoculated vs control lipids. Further studies were conducted on the 2 major "building blocks" of lipids, namely fatty acids and sterols. The compositions of these 2 lipids are given in Tables 1 and 2. Four acids were present in M roots but not in C roots: A) 12-hexadecenoic[a], B) 6,9,12-octadecatrienoic[a], C) 8,11,14-eicosatrienoic and D) 5,8,11,14-eicosatetraenoic acids. The C_{18} trienoic acid (B) was detected in the very low range of 0.1 to 0.5% and thus was not calculated in the C_{16}-C_{20} major acids. Campesterol showed the greatest difference between M and C roots and consisted of 96% of the sterols isolated from the fungus (Table 2).

With sour orange rootstock the influence of the 3 fungal species in producing these unusual fatty acids were G. etunicatus > G. fasciculatus > G. mosseae; the same sequence which was observed from top weight studies (2). Acids A-D in Table 1 were not present in seedlings grown on sterile soil supplemented with phosphate so as to produce plants equal in health and growth to M seedlings. These same acids also were not present in the tap roots and leaves of M seedlings. These acids were present in roots of 2-year and 9-year citrus plants, however their percentages, relative to the other C_{16}-C_{20} acids, decreased with age of plant. The fungal chlamydospores when compared with M roots contained less C_{18} acids and about the same amount of acid A. Fatty acids B, C and D, however, were essentially absent in the spores. A C_{20} acid (E) present at 14% (triglycerides) in the spore, was shown to be 5,8,11,14,17-eicosapentaenoic acid.

The fatty acid biochemical synthesis sequence pentaene → tetraene → triene → diene → monoene → saturates has not been reported to occur in plants. Thus, these data indicate the fungus gives 4 of the 5 fungi-animal type fatty acids to the host, mainly as triglycerides and to a lesser extent as phospholipids. The fifth acid (E) was not translocated to the host.

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[a]Tentative structures.

Table 1. Major C_{16}-C_{20} fatty acids in total lipids of mycorrhizal and nonmycorrhizal citrus roots and in chlamydospore triglycerides

Fatty acid*	Relative percent in lipid a	b	c	d	e	f	g	h
I16	6.3	2.0	2.9	3.4	1.8	1.4	1.5	2.1
16 + 16:1w7	33.7	15.9	34.1	38.8	29.9	24.0	24.8	29.9
AI17	1.5	2.5	1.5	1.9	2.7	1.2	1.1	2.3
18 + 18:1 + 18:2 + 18:3	58.5	15.8	21.6	18.9	65.6	43.6	55.1	9.5
16:1w4 (A)	-**	59.5	38.3	35.1	-	27.3	16.2	41.9
18:3w6 (B)	-	tr***	tr	tr	-	tr	tr	-
20:3w6 (C)	-	1.5	0.8	1.0	-	0.9	0.5	-
20:4w6 (D)	-	2.8	0.8	0.8	-	1.6	0.8	-
20:5w3 (E)	-	-	-	-	-	-	-	14.3

*I - Iso-branched, AI - Anteiso-branched, number of carbons in chain: number of double bonds present in chain, w - carbon from carboxyl end of chain at which the first double bond is present.
**Not detected at a level of 0.1%.
***Greater than 0.1 but less than 0.5% - not calculated in C_{16}-C_{20} fatty acids.
a - Control.
b - *G. etunicatus*.
c - *G. fasciculatus*.
d - *G. mosseae*.
e - Phosphate supplemented rough lemon.
f - Field grown 2-year Carrizo.
g - Field grown 9-year grapefruit.
h - Triglycerides of *G. mosseae* chlamydospores.

Table 2. Relative percent desmethyl free sterols in *G. mosseae* chlamydospores (S), control (C) and infected (M) citrus roots with *G. mosseae*.

Sterol	Relative % in S	C*	M*	M-C
Cholesterol	0.9	2.7	1.1	-1.6
Campesterol	96.0	32.1	41.9	9.8
Stigmasterol	0.3	20.2	19.1	-1.1
β-Sitosterol	2.8	42.7	36.9	-5.8
Isofucosterol	-**	2.3	1.0	-1.3

*Average values, 3 replicates, 6 rootstocks.
**Not detected at 0.1%.

LITERATURE CITED

1. Kleinschmidt, G. D. and Gerdemann, J. W. 1972. Phytopathology 62:1447.
2. Nemec, S. 1978. Proc. Fla. State Hortic. Soc. 91:10.

REFRIGERATED STORAGE OF UNPASTEURIZED MANGO SECTIONS

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The demand for fresh mangos in the Eastern U.S. market is satisfied by fruit produced on approximately 1500 acres in South Florida and by imports from Mexico. The supply-demand relationship in the U.S. has not spawned a processing industry but several products are described in the literature that may develop a market on their own. Refrigerated, pasteurized slices are most promising. The flavor and color are preserved during storage. One problem with the product is that heat pasteurization destroys the smooth firm texture of the fresh fruit. After heating the slices became stringy and mushy and they continue to degrade during storage. Alternatives to heat pasteurization for protection against microbial degradation are available. However, if autolysis of unheated tissue persists under refrigeration, a method of controlling enzymic degradation must be developed to preserve the texture, flavor and color during storage. We report on chemical and physical changes of quarter slices of unheated mangos stored for 6 weeks at 4°C.

Ripe mangos were peeled and quartered, placed in individual plastic bags and stored at 4°C. One quarter from each of 3 mangos was withdrawn from storage after 0, 2, 4 and 6 weeks and evaluated for quality (flavor and texture) by panels of tasters. Quarters from 6 mangos were withdrawn in the same sequence; one portion was assayed for shear resistance and the remainder was frozen in liquid N_2 and stored at -70°C. The frozen stored mangos were blended to a fine powder in a high speed Waring Blendor, thawed, and analyzed at the end of the six-week storage period for alcohol insoluble solids (AIS), pectic substances, and the enzymes, cellulose, pectin methylesterase and polygalacturonase.

Mango sections retained flavor of fresh fruit after storage for 6 weeks at 4°C. The taste panel scored the sections 3.3 and the fresh fruit 2.8 on a scale of 1 to 9, where 1 = like extremely, and 9 = dislike extremely. Texture of the mango sections changed during storage. Sections stored 2 weeks were scored 3.6 and fresh sections 2.2. Sections stored 4 and 6 weeks were scored less acceptable than sections stored 2 weeks.

Firmness of mango sections, measured as resistance to a shearing force, declined during storage at 4°C (Table 1). After 2 weeks the mean resistance of 6 samples decreased from 4.85 to 3.55 lbs, after 4 weeks the mean resistance was reduced to 2.10 lbs.

Storage of mango sections resulted in decrease in water soluble pectin (Table 2). After 2 weeks at 4°C the mean value of 6 samples declined to 23.1%, from an original value of 27.5% of AIS. The pectin level remained near this lower value after storage for 4 and 6 weeks.

During storage the ammonium oxalate soluble (pectate) content of individual mango sections varied between 3.1 and 7.8. The means for each storage period ranged from a low of 4.8 at 2 weeks to 5.5 at 4 weeks (Table 2). These data indicate that the pectate content was relatively constant during storage.

Alkali soluble pectin (protopectin) content of mango sections decreased during storage (Table 2). Individual fruits showed a consistent pattern of lower values for stored sections. After 4 weeks the mean protopectin value for six fruit declined 40% below the original value. The total pectin (sum of water, ammonium oxalate and sodium hydroxide soluble) declined from 37.5% of AIS to 31.8% during 6 weeks at 4°C (Table 2). Apparently some pectic substances became soluble in alcohol during storage and were not totally recovered in AIS.

The progressive decline in protopectin in mango sections correlates with loss of firmness during storage. A plot of the protopectin as % of AIS vs firmness as measured in lbs of shear show a linear correlation fitting the equation $\hat{y} = -2.55 + 1.47\ (x)$ with a coefficient of $r^2 = 0.95$. This observation is in agreement with the hypothesis that conversion of insoluble pectin to soluble forms is important in the mechanism of fruit softening (1). Softening of mango sections during storage could represent continuation of the softening process initiated during the ripening stage.

Cellulase activity of mango sections in storage increased two-fold after 6 weeks at 4°C. Polymethylesterase activity declined about 30%. These enzymes are probably active in the changes observed in the AIS fraction of mangos during storage. Pectic enzymes catalyzes the conversion of protopectin to its soluble form and also the degradation of pectin to alcohol soluble pectates. Cellulase has been linked to softening during ripening of peaches by Pressey (1). Modified atmosphere (low O_2 under hypobaric conditions) slowed solubilization of pectin and tissue softening in ripening of apples (2). Agents that modify pectic changes should be evaluated for their effect on storage stability of mango sections.

Table 1. Firmness of fruit sections from 6 mangos after storage at 4°C.

Storage	Resistance to shearing force (lb/sample)[a]						
weeks	1	2	3	4	5	6	Mean
0	3.2	4.5	7.6	5.0	4.7	4.1	4.8
2	2.7	3.0	5.0	3.8	3.4	3.4	3.6
4	1.4	1.4	2.5	3.0	2.2	2.2	2.1
6	1.3	1.3	2.2	2.3	2.0	2.0	1.8

[a]Each value is average of two measurements.

Table 2. Pectin content in mango sections after storage at 4°C

Storage weeks	Pectin (% of AIS)[a] Water Sol.	Amm. Ox. Sol.	Alk. Sol.	Total
0	27.5 ± 2.4	5.0 ± 1.6	5.0 ± 0.4	37.5
2	23.1 ± 4.6	4.8 ± 0.9	4.1 ± 0.7	32.0
4	21.7 ± 3.9	5.5 ± 1.8	3.0 ± 0.6	30.2
6	23.3 ± 4.0	5.2 ± 1.3	3.3 ± 0.5	31.8

[a]Mean values for six fruit ± SD.

LITERATURE CITED

1. Pressey, R., R. L. Ory and A. J. St. Angelo, Eds. 1977. ACS Symposium Series 47:172.

2. Knee, M. 1974. Colloques Internationale No. 238, CNRS, Paris. p. 341-345.

LOW ENERGY WATER REMOVAL FROM HEAT SENSITIVE LIQUID FOODS

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Anyone interested in obtaining details of this presentation, see Mr. Strolle and he will send a reprint of the publication from which it is taken, or write him at Eastern Regional Research Center, 600 E. Mermaid Lane, Philadelphia, Pennsylvania 19118.

DEVELOPMENT OF AN INEXPENSIVE AND EFFECTIVE SOLAR DRYER FOR FOODS AND CROPS

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The Citrus and Subtropical Products Laboratory has been involved for several years with the evaluation of solar dryers, solar drying of fruits and vegetables and pretreatments to enhance the color, flavor and shelf-life of solar dried fruits and vegetables. At the request of the Department of Energy, this laboratory designed, built and is currently testing several inexpensive but highly effective parabolic solar food dryers.

Figure 1 demonstrates the general design of a parabolic solar food dryer constructed early this year. This insolation concentrating dryer incorporates an aluminum foil reflector (A) drawn tightly over strings stretched taut between a framework of laminated wood parabolas (B). These laminated wood parabolas are constructed to focus at 10 inches. Aluminum foil partially defocuses this insolation spreading it over an 18-in. x 47.5 in. porous aluminum drying tray (C).

Figure 2 shows a side view of the parabolic solar food dryer. Dotted lines indicate polyethylene glazing, an inexpensive transparent protective cover (A) with variable openings (B & C) for controllable convection draft through the drying tray (D).

Experimental solar drying of peaches, mangos, mushrooms and four varieties of Muscadine grapes (Cowart, Fry, Higgins and Welder) have been successfully dried using this parabolic solar food dryer. Moisture contents of two solar dried muscadines over a three-day test are shown in Table 1.

These parabolic solar dryers have proven to be inexpensive and effective food dryers producing dried products with acceptable color, flavor and shelf-life using no fossil fuels.

Table 1. Moisture content of solar dried grapes (%).

Sample	Variety: Cowart	Variety: Welder
Fresh	78.7	81.9
Whole after 6 hrs	65.9	70.1
Whole after 20.5 hrs	11.6	9.4
Halved after 6 hrs	28.7	29.2
Halved after 13.5 hrs	9.8	15.0
Halved after 20.5 hrs		6.1

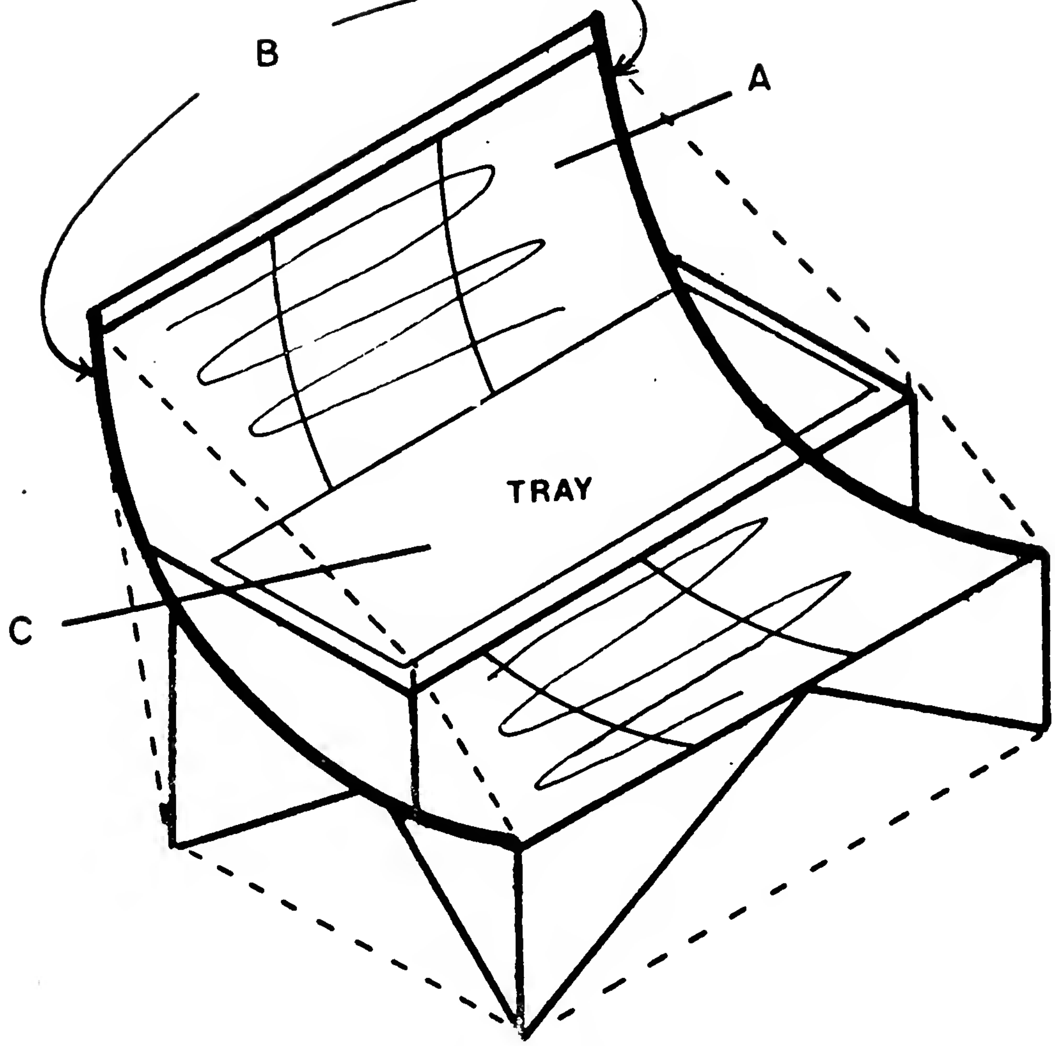

FIGURE 1

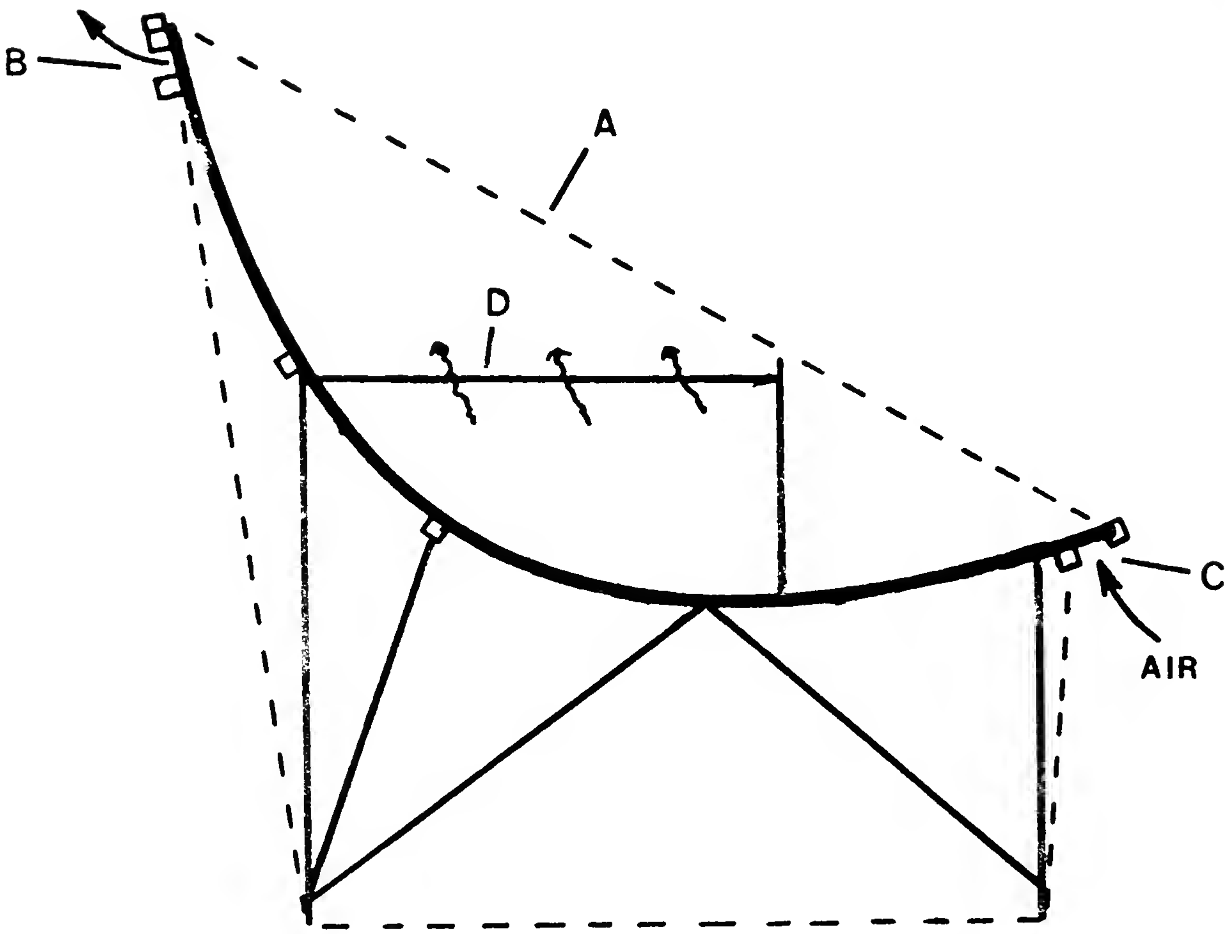

FIGURE 2

MECHANICAL GRADING AND TRASH REMOVAL EQUIPMENT FOR CITRUS PROCESSING PLANTS

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Florida Citrus Research Foundation
(Supported by the Florida Department of Citrus)
Lakeland, Florida

Project objective

Develop improved commercial equipment and procedures for removing trash, attached stems and unwholesome fruit from mechanically-harvested fruit loads at processing plants and assist with adapting the system to the plants.

Production prototype grading system

The mechanical trash removal and grading system that was installed at Winter Garden early in the 1977-78 season has now run early, mid and late season oranges and also several loads of grapefruit and has been found to be effective on all varieties run. This past year was the first time that early season fruit had been run on any of our systems. Initially, very fragile Hamlin oranges showed a tendency to be split by the grading portion of the system, however, several minor changes to the system appeared to solve the splitting problem. Although some details of equipment structure were changed, such as replacing the divider tip with a water filled rubber tube, the basic concept of the system is still as shown in Figures 1 and 2.

Figure 1 is a schematic of the prototype installed on Winter Garden C.P.C.'s #3 unloading line. The fruit was elevated to two large trash removal belts which effectively removed nearly all of the leaves, sticks and other trash and many of the worst cull fruit. The remaining fruit was conveyed to the roller feeder in the mechanical grading portion of the system (Figure 2) which dropped the fruit onto a steel drum where the firmer fruit (generally the best fruit) bounced farther from the drum than soft, decayed or split fruit. A barrier was set to separate the fruit into 2 streams according to the distance bounced so that portion which projected beyond the barrier was good enough for bin storage without further grading. The normally much smaller portion of the load which fell short of the barrier typically contained about half of all the culls, including all of the rotten and broken fruit. After manual grading, the good fruit in the smaller stream were recombined with the larger stream and conveyed to the bins.

Tests have shown that manual grading of this smaller stream is about three times as effective as manually grading the whole load. Including the culls removed by the trash belts, the system is about five times as effective as manual grading.

Lab tests at USDA

Paddle grader

Modifications to a paddle wheel grader constructed the previous year at the USDA in Winter Haven made this a very effective grader. In some tests over 70% of the culls were removed without removal of good fruit. The

paddle impact velocity on the fruit is identical to the fruit impact velocity on the drum with the drum rebound system. The primary advantage of the paddle wheel system is that there is very little elevation change required from the feeder to the catch belt. Thus, it is potentially applicable to more existing unloading stations, at lower cost, than the drum system.

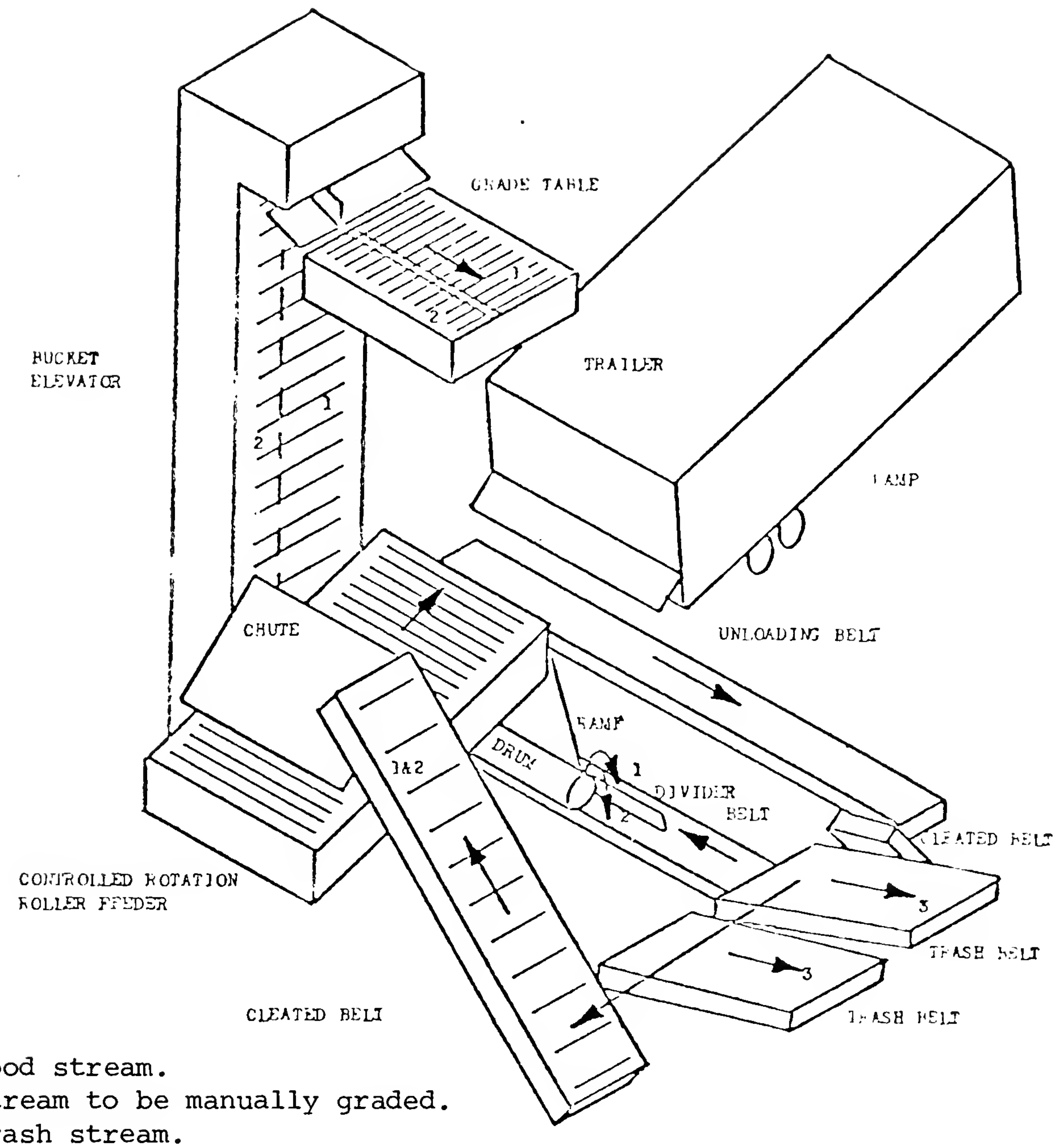
Destemmer

A single-lane experimental device that transported stemmed fruit while aligning and removing the stem was built and tested. A single moving V-belt accomplished all three functions.

Plant studies

Following the demonstration that the system could run fragile fruit and grapefruit, and the determinations of motor sizes and capacity of the prototype system, the plant assistance phase of the project was begun. Of the several lines studied to date, no two have been found alike. Enhancing the opportunities for widespread use of the system, will help make mechanically harvested fruit generally acceptable at no hardship to processing plants nor to those doing the mechanical harvesting. The project therefore provides a design layout service to adapt the system to any juice plant whose personnel express a definite interest.

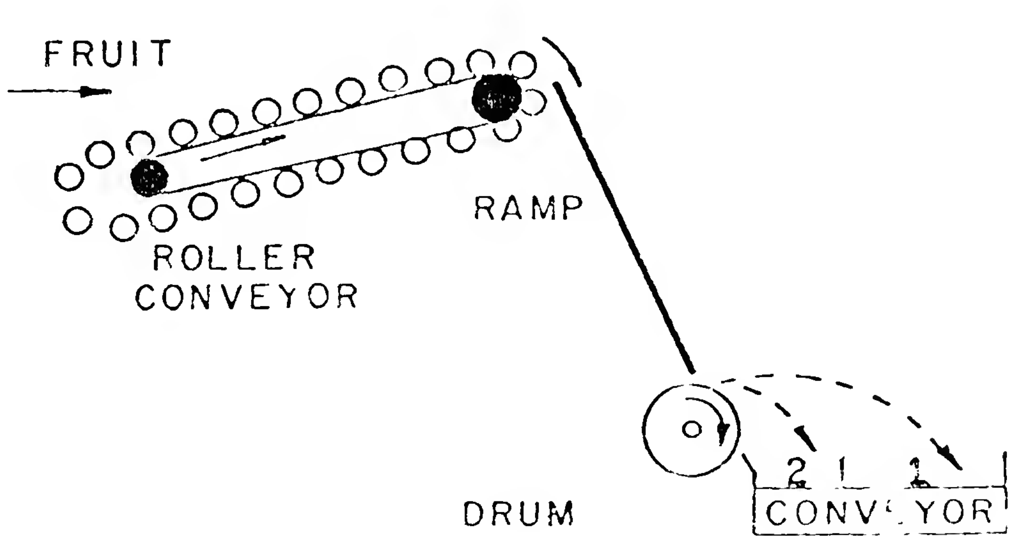
FIGURE 1



1- Good stream.
2- Stream to be manually graded.
3- Trash stream.

PRODUCTION PROTOTYPE MECHANICAL GRADING SYSTEM

FIGURE 2



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LIST OF PUBLICATIONS AND PATENTS

(September 1, 1978 - August 31, 1979)

Reprints of publications may be obtained without cost by addressing requests to the laboratory listed.

Patents may be obtained only by purchase from the U. S. Patent Office, Washington, D.C. 20250, for 50¢ each.

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RECOVERY OF CITRUS PIGMENTS FROM PROCESSING WASTE--AN OVERVIEW
Charles W. Wilson, III and Philip E. Shaw
Proc. Int. Soc. Citriculture 3, 808-810 (1977).

ORANGE JUICE FLAVOR: CONTRIBUTION OF CERTAIN VOLATILE COMPONENTS AS EVALUATED BY SENSORY PANELS
Philip E. Shaw, Esam M. Ahmed and Raymond A. Dennison
Proc. Int. Soc. Citriculture 3, 804-807 (1977).

ABSCISSION CHEMICAL AND ETHYLENE GAS EFFECTS ON ESSENTIAL OIL COMPOSITION AND FLAVOR OF ORANGE JUICE
Manuel G. Moshonas, Philip E. Shaw and Donald A. Sims
Proc. Int. Soc. Citriculture 3, 802-804 (1977).

QUALITY FACTORS IN SINGLE-STRENGTH AND CONCENTRATED ORANGE JUICE
Robert E. Berry
Proc. Int. Soc. Citriculture 3, 777-781 (1977).

HANDLING AND GRADING OF ORANGES IN PROCESSING PLANTS
William L. Bryan
Proc. Int. Soc. Citriculture 3, 763-768 (1977).

PROCESSES TO CONTROL JUICE CLOUD
Robert A. Baker
Proc. Int. Soc. Citriculture 3, 751-755 (1977).

CITRUS ENZYME SYSTEMS: OPPORTUNITIES FOR CONTROL OF FRUIT QUALITY
Joseph H. Bruemmer, Bela S. Buslig and Bongwoo Roe
Proc. Int. Soc. Citriculture 3, 712-716 (1977).

FLAVANONE CONTRIBUTION OF PARENT PLANTS TO EREMOCITRUS GLAUCA (LINDL.) SWING. HYBRIDS
Jack C. Lastinger, Jr., Herbert C. Barrett and James H. Tatum
Proc. Fla. State Hortic. Soc. 91, 198-200 (1978).

PRELIMINARY EVALUATIONS OF SULFITE PRETREATMENTS FOR SUN-DRIED AND HOT AIR-DRIED GREEN PEPPERS
Richard L. Coleman, Charles J. Wagner, Jr., William L. Bryan and Robert E. Berry
Proc. Fla. State Hortic. Soc. 91, 146-148 (1978).

PRELIMINARY STUDIES ON SO_2 ABSORPTION IN MANGOS, NECTARINES AND PEACHES PREPARED FOR DRYING
Charles J. Wagner, Jr., Richard L. Coleman, William L. Bryan and Robert E. Berry
Proc. Fla. State Hortic. Soc. 91, 117-119 (1978).

SECTIONIZING GRAPEFRUIT BY ENZYME DIGESTION
Joseph H. Bruemmer, Alicia W. Griffin and Oladipo Onayemi
Proc. Fla. State Hortic. Soc. 91, 112-114 (1978).

GAS-LIQUID CHROMATOGRAPHIC DETERMINATION OF LIMONENE IN ORANGE JUICE
Eric D. Lund and Philip E. Shaw
J. Assoc. Off. Anal. Chem. 62(3), 477 (1979).

FATTY ACID PROFILES OF ESTERIFIED STEROL GLUCOSIDES (ESG) FROM JUICE VESICLES OF CITRUS FRUITS
Harold E. Nordby and Steven Nagy
Phytochemistry 18, 825-827 (1979).

REVIEW OF QUANTITATIVE ANALYSES OF CITRUS ESSENTIAL OILS
Philip E. Shaw
J. Agric. Food Chem. 27(2), 246-257 (1979).

CAUSTIC WASTE DISPOSAL ON LAKELAND FINE SAND. A POTENTIAL LANDSPREADING PROBLEM
Richard L. Coleman, Philip E. Shaw and Donald A. Sims
J. Agric. Food Chem. 27(2), 402-406 (1979).

ANALYSIS OF MONOSACCHARIDES IN AVOCADO BY HPLC
Charles W. Wilson, III, Philip E. Shaw and Steven Nagy
Analysis of Food & Beverages: Volume 1, Academic Press, Inc., pp. 225-236. (1979).

RESPONSE AMPLIFICATION OF HISTIDINE IN GAS-LIQUID CHROMATOGRAPHIC ANALYSIS OF AMINO ACID MIXTURES
Nancy T. Hall and Steven Nagy
J. Chromatog. 171, 392-397 (1979).

RELATIONSHIP OF ROOTSTOCK TO LEAF AND JUICE LIPIDS IN CITRUS
Harold E. Nordby, Steven Nagy and John M. Smoot
J. Amer. Soc. Hortic. Sci. 104(2), 280-282 (1979).

SOLANUM PLATANIFOLIUM: STUDIES ON THE PETROLEUM ETHER EXTRACTS OF ROOTS, STEMS AND LEAVES
Ravinder K. Puri, J. K. Bhatnagar, Harold E. Nordby and Steven Nagy
Lloydia 41(6), Nov.-Dec., 634 (1978).
NO REPRINTS AVAILABLE.

SUBTROPICAL FRUITS OF THE SOUTHERN UNITED STATES
Robert E. Berry
Tropical Foods, Volume 1, Academic Press, Inc., Pgs. 95-110 (1979).

RECENT STUDIES IN FLAVOR CHEMISTRY, CHEMURGY, AND SOLAR DRYING TECHNOLOGY OF SOME TROPICAL FRUITS
Robert E. Berry, Richard L. Coleman, Charles W. Wilson, III and Charles J. Wagner, Jr.
Tropical Foods, Volume 1, Academic Press, Inc., Pgs. 111-123 (1979).

CITRUS JUICE PRODUCTS
Robert E. Berry
Tropical Foods, Volume 1, Academic Press, Inc., Pgs. 125-139 (1979).

ENERGY FLUX VALUES TO A SOLAR FOOD DRYER FROM MODIFIED SOLAR CELLS
Charles J. Wagner, Jr., William L. Bryan and Jere M. Miller
Proc. Annual Meeting, American Section ISES, Vol. 2.1, pgs. 33-36 (1978)

COUMARINS AND PSORALENS IN GRAPEFRUIT PEEL OIL
James H. Tatum and Robert E. Berry
Phytochemistry 18, 500-502 (1979).

CITRUS ESSENTIAL OILS
Philip E. Shaw
Perfumer & Flavorist 3(6), 35-40 (1979).

SELECTED LEAF WAX ALKANES IN CHEMOTAXONOMY OF CITRUS
Harold E. Nordby, Steven Nagy and John M. Smoot
J. Amer. Soc. Hortic. Sci. 104(1), 3-8 (1979).

FATTY ACID PROFILES OF THREE SWEET ORANGE CULTIVARS DURING MATURATION
Harold E. Nordby and Steven Nagy
J. Agric. Food Chem. 27(1), 15-19 (1979).

ISOLATION OF TRANS,TRANS-2,4-DECADIENAL AND INTERMEDEOL FROM COLD-PRESSED CITRUS OILS
Manuel G. Moshonas and Philip E. Shaw
J. Agric. Food Chem. 27(1), 210-211 (1979).

MECHANICALLY ASSISTED GRADING OF ORANGES FOR PROCESSING
William L. Bryan, Barry J. Anderson and Jere M. Miller
Trans. ASAE 21(6), 1226-1231 (1978).

FOOD DRYING WITH DIRECT SOLAR AUGMENTED BY FOSSIL ENERGY
William L. Bryan, Charles J. Wagner, Jr. and Robert E. Berry
Trans. ASAE 21(6), 1232-1236 & 1241 (1978).

SEPARATION OF NUCELLAR AND ZYGOTIC CITRUS SEEDLINGS BY THEIR FLAVONOIDS AND OTHER NON-VOLATILE COMPONENTS
James H. Tatum, Robert E. Berry and C. Jack Hearn
Proc. Int. Soc. Citriculture 2, 614-616 (1977).

DEVICE AND METHOD OF DIRECT INTRODUCTION OF MATERIALS INTO MASS SPECTROMETERS FROM ADSORBANTS
Manuel G. Moshonas
U. S. Patent No. 3,583,234: June 8, 1971.
(Assigned to the U. S. Gov't. as represented by the Secretary of Agriculture.)
NO REPRINTS AVAILABLE.

QUANTITATIVE COMPOSITION OF COLD-PRESSED GRAPEFRUIT OIL
Charles W. Wilson, III and Philip E. Shaw
J. Agric. Food Chem. 26(6), 1432-1434 (1978).

COMPOUNDS NEW TO ESSENTIAL ORANGE OIL FROM FRUIT TREATED WITH ABSCISSION CHEMICALS
Manuel G. Moshonas and Philip E. Shaw
J. Agric. Food Chem. 26(6), 1288-1290 (1978).

SYNTHESIS OF NOOTKATONE FROM VALENCENE
Charles W. Wilson, III and Philip E. Shaw
J. Agric. Food Chem. 26(6), 1430-1432 (1978).

METHOD OF DENSIFYING FOOD PRODUCTS
Robert E. Berry, Owen W. Bissett, Charles J. Wagner, Jr. and Eldridge P. Patterson
U. S. Patent No. 3,672,909: June 27, 1972.
(Assigned to the U. S. Gov't. as represented by the Secretary of Agriculture.)
NO REPRINTS AVAILABLE.

THIN LAYER AND HIGH PRESSURE LIQUID CHROMATOGRAPHIC ANALYSIS OF CELERY SEED OIL
Eric D. Lund
J. Assoc. Offic. Anal. Chem. 61(5), 1083-1088 (1978).

POTENTIAL FOOD USES FOR PROTEIN FROM TROPICAL AND SUBTROPICAL PLANT LEAVES
Steven Nagy, Lehel Telek, Nancy T. Hall, and Robert E. Berry
J. Agric. Food Chem. 26(5), 1016-1028 (1978).

DIRECT SOLAR DRYING OF FRUITS AND VEGETABLES IN THE SOUTHEASTERN UNITED STATES
William L. Bryan
Proc. Conf. on Energy Use Management, Vol. III/IV (1977).

EFFECT OF NONANAL, CITRAL, AND CITRUS OILS ON GERMINATION OF CONIDIA OF PENICILLIUM DIGITATUM AND PENICILLIUM ITALICUM
R. C. French, R. K. Long, F. M. Latterell, C. L. Graham, J. J. Smoot and P. E. Shaw
Phytopathology 68(6), 877-882 (1978).

TERPENE HYDROCARBONS FROM PSIDIUM GUAJAVA
Charles W. Wilson, III and Philip E. Shaw
Phytochemistry 17, 1435-1436 (1978).

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Pasadena, California 91106

NON-PARAMETRIC METHODS FOR DETECTION OF ADULTERATION OF CONCENTRATED ORANGE JUICE FOR MANUFACTURING.
Thomas F. Schatzki and Carl E. Vandercook
JAOAC, 61, 911-917 (1978).

HIGH PRESSURE LIQUID CHROMATOGRAPHIC DETERMINATION OF IMAZALIL RESIDUES IN CITRUS FRUITS.
Shirley M. Norman and David C. Fouse
JAOAC, 61, 1469-1474 (1978).

DIHYDROCHALCONE SWEETENERS.
R. M. Horowitz and Bruno Gentili
Proc. of Conference on Sugar Substitutes, Geneva, Switzerland, Karger, Basel, pp 166-171 (1978).

CIRCULAR DICHROISM OF C-GLYCOSYLFLAVONES.
William Gaffield, Robert M. Horowitz, Bruno Gentili, Jean Chopin and Marie-Louise Bouillant
Tetrahedron, 34, 3089-3096 (1978).

BIOREGULATION OF CITRUS TERPENOID CONSTITUENTS AND FRUIT QUALITY.
V. P. Maier, Linda C. Brewster, Shirley M. Norman and Henry Yokoyama
in Tropical Foods: Chemistry and Nutrition, Volume 1 (1979), G. E. Inglett and G. Charalambous, Eds., Academic Press, New York, pp 155-170.

EASY METHOD DETECTS JUICE DILUTION.
Carl E. Vandercook and Dora Smolensky
Fd. Product Development, 13(1), 60-61 (1979).

TASTE AND STRUCTURE RELATIONS OF FLAVONOID COMPOUNDS.
R. M. Horowitz and Bruno Gentili
Proc. Fifth International Congress of Food Science and Technology, 1978, Kyoto, Japan, in press.

CHEMICAL COMPOSITION OF DATES AS RELATED TO NUTRITIVE VALUE AND QUALITY.
Carl E. Vandercook, Shin Hasegawa and Vincent P. Maier
in Nutrient Composition and Flavor Qualities of Tropical and Subtropical Fruits, Steven Nagy and Philip E. Shaw, Eds., AVI Publishing Company, Inc., in press.

THE BIOCHEMICAL BASIS OF FRUIT COMPOSITION AND QUALITY.
V. P. Maier and Linda C. Brewster
Proc. International Society of Citruculture, 1977, Volume 3, in press.

BIOREGULATORS AND CITRUS FRUIT COLOR.
H. Yokoyama, J. Hsu, S. Poling, E. Hayman and C. DeBenedict
Proc. International Society of Citruculture, 1977, Volume 3, in press.

FLAVONOIDS: USES AND BYPRODUCTS.
R. M. Horowitz and Bruno Gentili
Proc. International Society of Citriculture, 1977, Volume 3, in press.